Chapter 3

Statewide Trends and Forecasts -- Criteria Pollutants

Introduction
Emission Trends and Forecasts

The most current emissions data available are from 2001. Any data prior to this year are derived from historical emissions data. Future year data are forecasted from the 2001 base year and control measures reported through September 2001. Forecasts take into account emissions data, projected growth rates, and future control measures to calculate emissions in future years.

Statewide Emissions (tons/day, annual average)								
	1975	1980	1985	1990	1995	2000	2005	2010
NO_x	4762	5050	4939	4901	4133	3523	2962	2462
ROG	6408	6210	5737	4595	3755	3117	2592	2331
PM_{10}	1813	1983	1985	2254	2221	2313	2447	2601
CO	38285	36315	34625	29631	22876	17937	14052	11423

Table 3-1

On a statewide basis, emissions of NO_x increased slightly between 1975 and 1985, but are declining between 1985 and 2010. Emissions of ROG are decreasing steadily between 1975 and 2010. In addition to being ozone precursors, both NO_x and ROG are secondary contributors to PM_{10}. In contrast to NO_x and ROG, direct PM_{10} emissions are increasing from 1995 to 2010, primarily due to increases in the number of vehicle miles traveled (VMT) on paved and unpaved roads. These VMT estimates are reported by Councils of Governments and local and regional air pollution control agencies. As a percent of area-wide sources, paved road dust accounts for 15 percent of the total in 1975, rising to 19 percent in 1995, and remaining steady at that level until 2010. As a percent of area-wide sources, unpaved road dust accounts for 20 percent of the total in 1975, rising to 32 percent of the total in 1995, and remaining steady at that level until 2010.

Emissions of CO have decreased since 1985. The recent decrease in NO_x, ROG, and CO is occurring even with increases of VMT and population levels.

Statewide Population and VMT

Airborne pollutants result in large part from human activities, and growth generally has a negative impact on air quality. California is fortunate in that it boasts the world's most progressive emission controls. These controls have resulted in significant air quality improvements, despite substantial growth.

During 1981 through 2000, statewide peak 1-hour ozone values decreased 47 percent, and peak 8-hour carbon monoxide values dropped 39 percent. These air quality improvements occurred at the same time the State's population increased 39 percent and the average daily number of vehicle miles traveled (VMT) increased 91 percent. Ambient annual geometric mean PM_{10} values in the non-desert areas also show improvement -- a 33 percent decrease from 1988 to 2000. While the air quality improvements are impressive, additional emission controls will be needed to offset future growth.

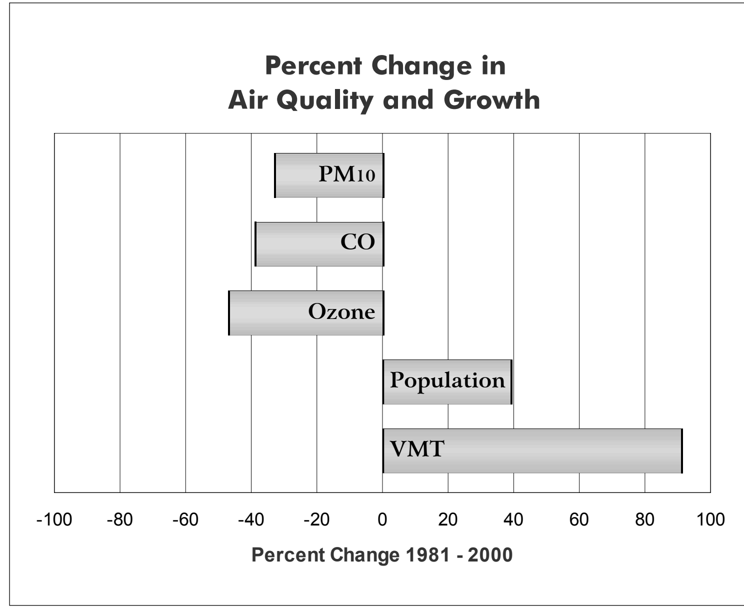

Figure 3-1

Ozone

Emission Trends and Forecasts - Ozone Precursors

NO_x Emission Trends and Forecasts

NO_x emission standards for on-road motor vehicles were introduced in 1971 and followed in later years by the implementation of more stringent standards and the introduction of three-way catalysts. NO_x emissions from on-road motor vehicles have declined by over 30 percent from 1990 to 2000, and NO_x emissions are projected to decrease by an additional 45 percent between 2000 and 2010. This has occurred as vehicles meeting more stringent emission standards enter the fleet, and all vehicles use cleaner burning gasoline and diesel fuel or alternative fuels. Stationary source NO_x emissions dropped by over 40 percent between 1980 and 1995. This decrease has been largely due to a switch from fuel oil to natural gas and the implementation of combustion controls such as low-NO_x burners for boilers and catalytic converters for both external and internal combustion stationary sources. State Implementation Plan (SIP) and conformity inventory forecasts may differ from the forecasts presented in this almanac. For additional information on these forecasts, please refer to the ARB SIP web page at *www.arb.ca.gov/sip/siprev1.htm*.

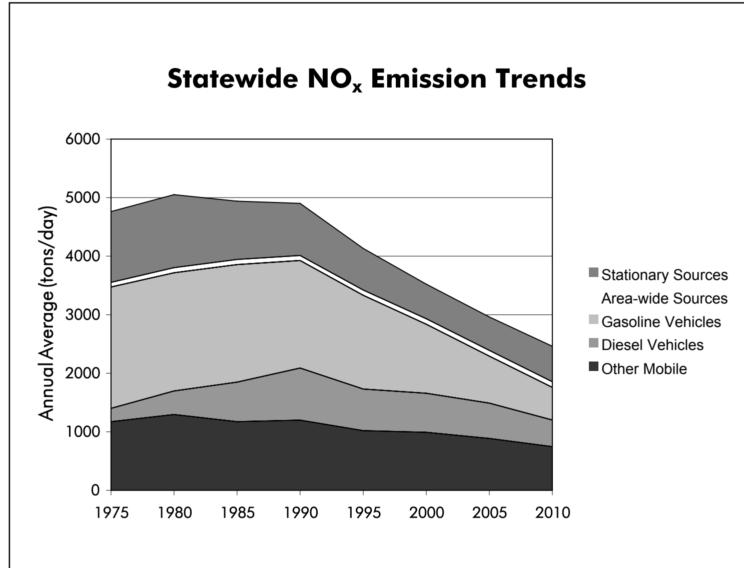

Figure 3-2

ROG Emission Trends and Forecasts

ROG emissions in California are projected to decrease by over 60 percent between 1975 and 2010, largely as a result of the State's on-road motor vehicle emission control program. This includes the use of improved evaporative emission control systems, computerized fuel injection, and engine management systems to meet increasingly stringent California emission standards, cleaner gasoline, and the Smog Check program. ROG emissions from other mobile sources are projected to decline between 1995 and 2010 as more stringent emission standards are adopted and implemented. Substantial reductions have also been obtained for area-wide sources through the vapor recovery program for service stations, bulk plants, and other fuel distribution operations. There are also on-going programs to reduce overall solvent ROG emissions from coatings, consumer products, cleaning and degreasing solvents, and other substances used within California. Again, State Implementation Plan (SIP) and conformity inventory forecasts may differ from the forecasts presented in this almanac. For additional information on these forecasts, please refer to the ARB SIP web page at *www.arb.ca.gov/sip/siprev1.htm*.

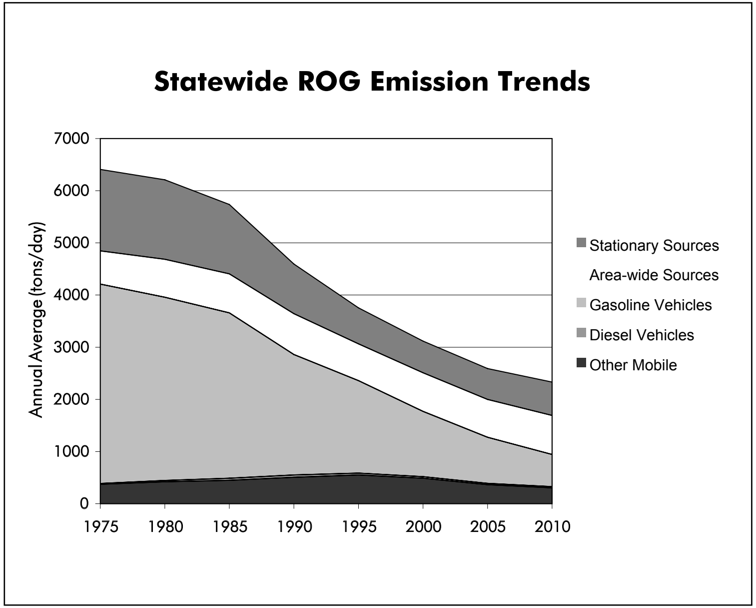

Figure 3-3

Emission Trends and Forecasts - Ozone Precursors

NOx Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***4762***	***5050***	***4939***	***4901***	***4133***	***3523***	***2962***	***2462***
Stationary Sources	1211	1246	994	889	711	592	571	606
Area-wide Sources	78	88	88	87	89	94	98	97
On-Road Mobile	2300	2422	2684	2727	2312	1846	1408	1012
Gasoline Vehicles	2074	2020	2007	1836	1602	1179	803	559
Diesel Vehicles	226	402	678	890	710	667	604	453
Other Mobile	1173	1294	1172	1199	1020	991	886	747

ROG Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***6408***	***6210***	***5737***	***4595***	***3755***	***3117***	***2592***	***2331***
Stationary Sources	1561	1524	1331	951	689	607	593	640
Area-wide Sources	637	728	749	784	706	740	725	747
On-Road Mobile	3837	3537	3209	2353	1809	1282	910	638
Gasoline Vehicles	3823	3512	3168	2308	1774	1252	883	616
Diesel Vehicles	15	26	41	45	35	30	27	22
Other Mobile	372	420	448	507	551	488	364	306

Table 3-2

Statewide Air Quality - Ozone

Air quality as it relates to ozone has improved greatly in all areas of California over the last 20 years, despite significant growth. The statewide trend, which reflects values for the South Coast Air Basin, shows the maximum peak 1-hour indicator declined 47 percent from 1981 to 2000. During this same time period, the population grew by 43 percent and the number of vehicle miles traveled each day was up more than 90 percent. Motor vehicles are the largest source category of ozone precursor emissions, and reducing their emissions will continue to be the cornerstone of California's ozone control efforts. New vehicles must meet the ARB's low emission vehicle standards, which equate to about 95 percent fewer smog-forming emissions than vehicles produced in the 1970s. However, increases in population and driving are partially offsetting the benefits of cleaner vehicles. In addition to motor vehicle controls, the ARB is establishing controls for other sources of ozone precursor emissions, such as consumer products. The ARB and other agencies are also looking at new and more efficient ways of doing business and implementing incentives to improve air quality.

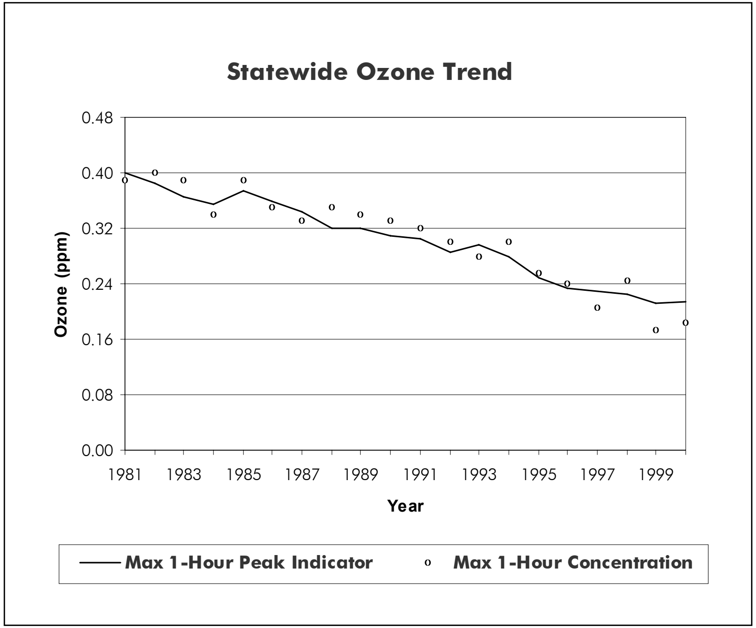

Figure 3-4

Population-Weighted Exposures Over the State Ozone Standard

There are a number of ways to look at how ozone levels have changed over the years. Though simple indicators are most commonly used, complex indicators can offer additional insight concerning air quality. One such indicator is the *population-weighted exposure* indicator. An "exposure" occurs when a person experiences a one-hour ozone concentration outdoors that is higher than 0.09 ppm, the level of the State standard. The population-weighted exposure indicator considers both the level and the duration of ozone concentrations above the State standard. The annual exposure is the sum of all the hourly exposures during the year and presents the result as an average per exposed person.

In contrast to the peak indicator, which provides an indication of the potential for acute adverse health impacts, the population-weighted exposure provides an indication of the potential for chronic adverse health impacts. For the purposes of computing the exposures in this almanac, individuals are presumed to have been exposed to the concentrations measured by the ambient air quality monitoring network. However, daily activity patterns (for example, being inside a building or exercising outdoors) may diminish or increase exposures to some outdoor concentrations that exceed the State standard. While many indicators characterize air quality at an individual monitoring location, the exposure indicator provides an integrated regional perspective. For each hour, the calculations simultaneously consider ozone data from all of the monitors in a region. People living in areas where ozone exceeds the standard are then included in the population-weighted exposure for that hour.

The examples below show two simple exposure calculations. First, a measured ozone concentration of 0.11 ppm for one hour represents an exposure of 0.02 ppm-hours above the State ozone standard of 0.09 ppm:

$$(0.11 \text{ ppm} - 0.09 \text{ ppm}) \times 1 \text{ hour} = 0.02 \text{ ppm-hours}$$

Second, a measured concentration of 0.10 ppm for two hours also equals an exposure of 0.02 ppm-hours:

$$(0.10 \text{ ppm} - 0.09 \text{ ppm}) \times 2 \text{ hours} = 0.02 \text{ ppm-hours}$$

In contrast to these examples, when the concentration is at or below the level of the State standard (0.09 ppm), the exposure is zero. These "zero" exposures are not included in the exposure calculations in this edition of the almanac because including the zero exposures dilutes the real impact of the ozone concentrations that are above the State standard and are, therefore, adversely affecting public health. In all cases, an exposure calculation that excludes the zero values will be higher than one incorporating concentrations at or below the level of the standard (areas of zero exposure).

The population-weighted exposures in Table 3-3 are listed for each year, from 1980 through 2000, for the five most populated areas of California: South Coast Air Basin, San Francisco Bay Area Air Basin, San Joaquin Valley Air Basin, San Diego Air Basin, and Sacramento Metropolitan Area. While these areas do not encompass all of California's ozone nonattainment areas, they do include the major urban areas where the majority of the State's population lives.

The values in Table 3-3 differ from the values reported in the previous edition of the almanac for two reasons. First, the air quality data are now presented in parts per million rather than parts per hundred million to be consistent with the units in which the State standard is expressed. This change caused all results to decrease by a factor of 100. Second, as noted earlier, only "exposed" people (people living in areas with concentrations above the State standard) now contribute to the hourly characterization of the average exposure. Previously, all people in the region, even those with "zero" exposure contributed to the exposure calculation. This change caused the exposure results to increase by a factor of 1.7 to 50, depending on the region and the year. Despite these changes, the time trends for the two types of exposure calculations are strongly correlated. In addition to the exposure values, Table 3-3 also lists the percent of the total population represented in the exposure value. The percent value reflects the percent of the total population in the area that was exposed to an ozone concentration above the level of the State standard for at least one hour during the year. Because the exposure result is an average, it may not accurately portray the exposure of any particular individual or subarea. Some people in the region experience higher exposure while others experience lower exposure. Nevertheless, this method provides a reasonable approach for comparing exposures among various regions and assessing trends in exposure reductions

The calculations for the exposure indicators are based on all concentrations measured in the area that satisfy the specified data requirements and use census information for 1990. General details about the computational procedure can be found in the ARB publication entitled: "*Guidance for Using Air Quality-Related Indicators in Reporting Progress in Attaining the State Ambient Air Quality Standards*" (September 1993).

Ozone Exposures Over the State Standard: Population-Weighted (ppm-hours / person)																					
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
South Coast Air Basin																					
Exposure	44.92	40.34	31.94	40.60	35.97	36.89	34.68	30.18	33.24	29.21	21.88	22.24	21.96	17.82	18.77	13.19	10.59	6.46	8.88	3.27	3.92
% Pop. Represented*	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	100%	92%	99%	99%	100%
San Francisco Bay Area Air Basin																					
Exposure	2.33	1.67	0.81	2.28	2.28	1.45	0.85	1.80	1.24	0.68	0.47	0.48	0.54	0.41	0.26	1.06	1.02	0.10	0.95	0.62	0.32
% Pop. Represented	100%	65%	57%	97%	100%	73%	46%	72%	73%	54%	41%	45%	50%	72%	40%	81%	60%	48%	54%	64%	23%
San Joaquin Valley Air Basin																					
Exposure	8.57	8.17	8.22	5.95	7.59	8.45	10.66	11.07	9.93	7.64	5.72	6.49	5.89	6.41	6.48	6.12	6.90	3.73	6.63	4.46	4.64
% Pop. Represented	93%	96%	98%	97%	97%	97%	94%	98%	99%	96%	96%	96%	96%	99%	99%	99%	99%	99%	99%	99%	99%
San Diego Air Basin																					
Exposure	8.30	10.88	7.22	10.04	6.97	8.27	5.24	5.65	7.44	7.34	6.50	3.97	3.34	2.75	2.28	2.41	1.19	0.83	1.91	0.60	0.59
% Pop. Represented	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	79%	100%	98%	100%	84%	70%	74%
Sacramento Metropolitan Area																					
Exposure	3.44	3.68	2.28	2.34	3.12	2.88	2.57	3.20	4.67	2.19	2.06	2.49	2.55	1.18	1.92	2.35	1.95	0.56	2.01	1.49	1.19
% Pop. Represented	97%	99%	96%	91%	97%	93%	91%	97%	97%	100%	97%	96%	100%	98%	94%	100%	100%	98%	98%	100%	97%

* *% Population Represented* is the percent of the total population in the area exposed to an ozone concentration above the level of the State standard for at least one hour during the year.

Table 3-3

Ozone Transport

Since 1989, the ARB staff has evaluated the impacts of the transport of ozone and ozone precursor emissions from upwind areas to the ozone concentrations in downwind areas. These 12 years with analyses demonstrate that the air basin boundaries are not true boundaries of air masses. All urban areas are upwind contributors to their downwind neighbors with the exception of San Diego. Figure 3-5 shows the flow of pollutants throughout the State. The ozone problem in some rural areas is caused almost solely by transported pollutants. These areas, although designated as nonattainment, are not required to adopt an air quality plan because local control strategies in these areas would not be effective in reducing ozone concentrations. However, these areas are subject to many statewide control strategies, such as cleaner fuels and low emission vehicles. More detailed information about ozone transport is available on the web at: *www.arb.ca.gov/aqd/transport/transport.htm*.

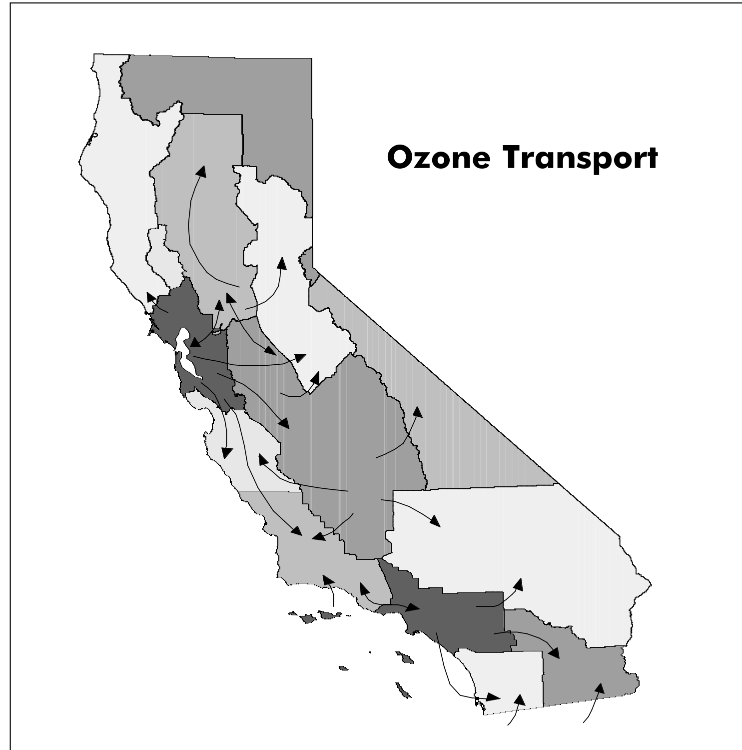

Figure 3-5

Particulate Matter (PM_{10})

Emission Trends and Forecasts - PM_{10}

The upward trend in statewide directly emitted PM_{10} emissions is primarily due to an increase in emissions from area-wide sources. This includes an increase in emissions of unpaved and paved road dust due to increases in vehicle miles traveled (VMT) over these roads. Exhaust emissions from diesel vehicles dropped by 55 percent from 1990 to 2000 due to more stringent emissions standards and the introduction of cleaner burning diesel fuel. PM_{10} emissions from stationary sources are expected to increase slightly in the future due to industrial growth.

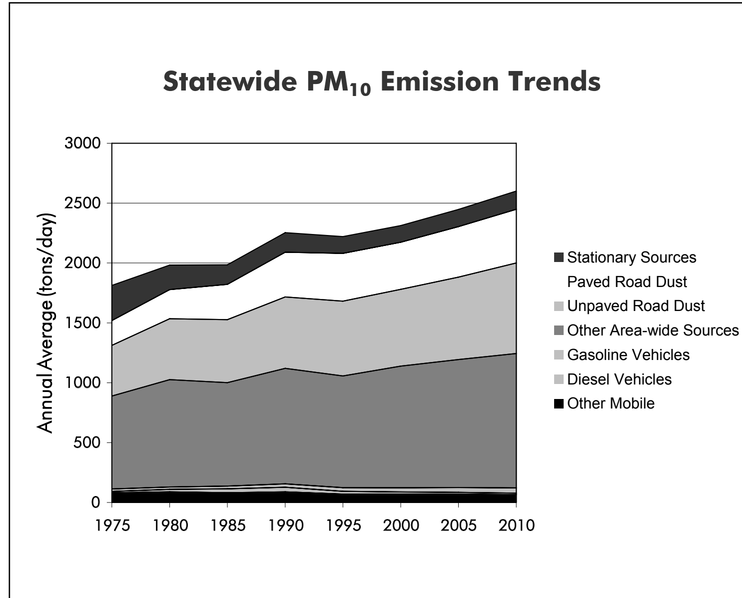

Figure 3-6

Emission Trends and Forecasts - PM_{10}

PM10 Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***1813***	***1983***	***1985***	***2254***	***2221***	***2313***	***2447***	***2601***
Stationary Sources	294	205	164	163	140	140	143	152
Area-wide Sources	1406	1649	1684	1935	1956	2050	2180	2328
Paved Road Dust	207	243	295	374	399	393	422	449
Unpaved Road Dust	423	509	526	596	625	642	688	756
Other Area-wide Sources	776	897	864	965	932	1016	1069	1123
On-Road Mobile	32	40	56	66	54	53	54	56
Gasoline Vehicles	21	20	23	28	31	35	40	44
Diesel Vehicles	11	20	33	38	23	17	14	12
Other Mobile	81	89	81	89	70	70	70	65

Table 3-4

Statewide Air Quality - PM_{10}

In contrast to ozone and carbon monoxide, PM_{10} concentrations do not relate as well to growth in population or vehicle usage, and high PM_{10} concentrations do not always occur in high population areas. Activities that contribute directly to high PM_{10} include wood burning, agricultural activities, and driving on unpaved roads. In addition, emissions from stationary sources and motor vehicles form secondary particles that contribute to PM_{10} in some areas. Figure 3-7 shows the maximum statewide annual geometric mean PM_{10} concentrations. The trend line reflects the South Coast Air Basin. The line shows a fairly steady decline over the period, reflecting an overall decrease of about 33 percent. However, there is a great deal of variability, especially during the latter years. Much of this variability may be due to meteorology rather than changes in emissions. Several more years of data are needed before making any judgement about the direction of the trend. Currently, over 99 percent of Californians breathe air that violates the State PM_{10} standards during at least part of the year. As a result, particulate matter is commanding greater attention, and much effort will be needed to attain the standards.

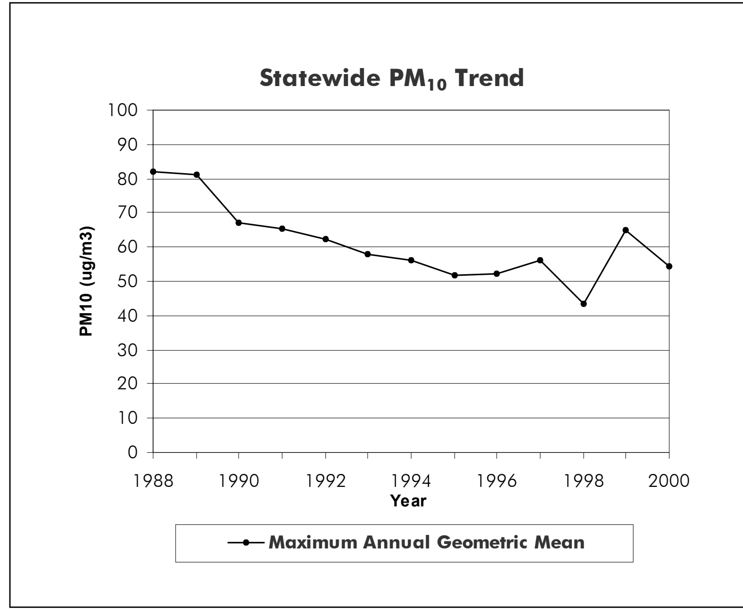

Figure 3-7

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Carbon Monoxide

Emission Trends and Forecasts - Carbon Monoxide

Since 1975, even though motor vehicle miles traveled (VMT) have continued to climb, the adoption of more stringent motor vehicle emissions standards has dropped statewide CO emissions from on-road motor vehicles by over 60 percent in 2000. With continued vehicle fleet turnover to cleaner vehicles including super ultra low emitting vehicles (SULEV's) and electric vehicles (EV's), and the incorporation of cleaner burning fuels, CO emissions are forecast to continue decreasing through the year 2010. CO emissions from other mobile sources are also projected to decrease through 2010 as more stringent emissions standards are implemented. CO emissions from area-wide sources are expected to increase slightly due to increased waste burning and additional residential fuel combustion resulting from population increases.

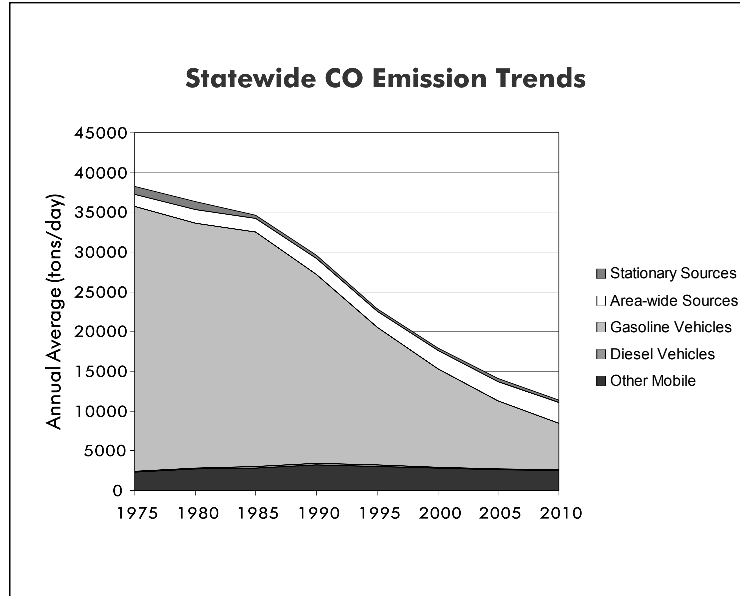

Figure 3-8

Emission Trends and Forecasts - Carbon Monoxide

CO Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***38285***	***36315***	***34625***	***29631***	***22876***	***17937***	***14052***	***11423***
Stationary Sources	1087	975	424	474	359	349	373	392
Area-wide Sources	1507	1667	1703	1935	1957	2274	2412	2565
On-Road Mobile	33352	31002	29692	24036	17503	12530	8633	5964
Gasoline Vehicles	33295	30900	29518	23829	17335	12393	8511	5861
Diesel Vehicles	57	103	175	206	167	137	122	102
Other Mobile	2339	2670	2806	3186	3057	2785	2634	2502

Table 3-5

Statewide Air Quality - Carbon Monoxide

Similar to ozone, carbon monoxide concentrations in all areas of California have decreased substantially over the last 20 years, despite significant growth. Statewide, the maximum peak 8-hour indicator declined about 39 percent from 1981 to 2000. Currently, the State and national carbon monoxide standards are violated in only two areas: the South Coast Air Basin portion of Los Angeles County and the city of Calexico, in Imperial County. The introduction of cleaner fuels has helped bring the rest of the State into attainment. While cleaner fuels will have a continuing impact on carbon monoxide levels, additional emission reductions will be needed in the future to keep pace with increases in population and vehicle usage. These reductions will come from continued fleet turnover, expanded use of low emission vehicles, and measures to promote less polluting modes of transportation. In addition, the introduction of zero emission vehicles will play an increasingly important role in the coming years.

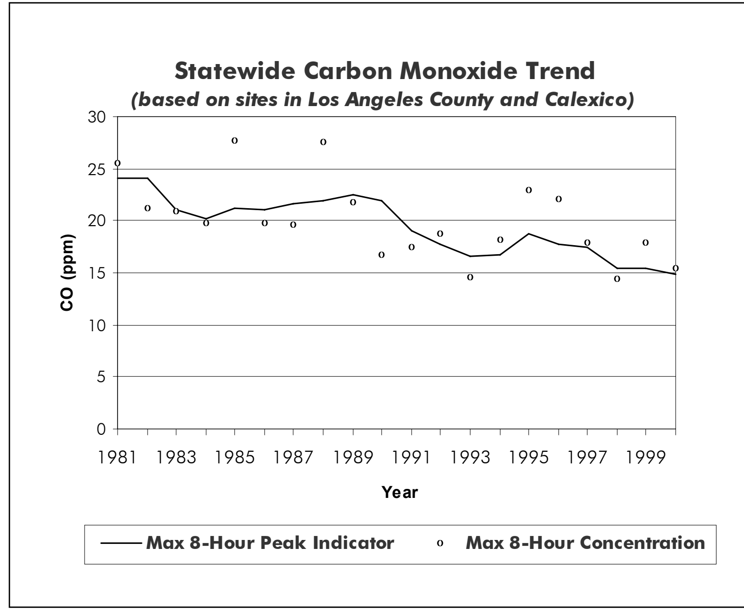

Figure 3-9

Success Stories

Statewide Air Quality - Lead

The decrease in lead emissions and ambient lead concentrations over the past 25 years is California's most dramatic success story. The rapid decrease in lead concentrations can be attributed primarily to phasing out the lead in gasoline. This phase-out began during the 1970s, and subsequent ARB regulations have virtually eliminated all lead from the gasoline now sold in California. All areas of the State are currently designated as attainment for the State lead standard (the United States Environmental Protection Agency does not designate areas for the national lead standard). Although the ambient lead standards are no longer violated, lead emissions from stationary sources still pose "hot spot" problems in some areas. As a result, the ARB identified lead as a toxic air contaminant in 1997.

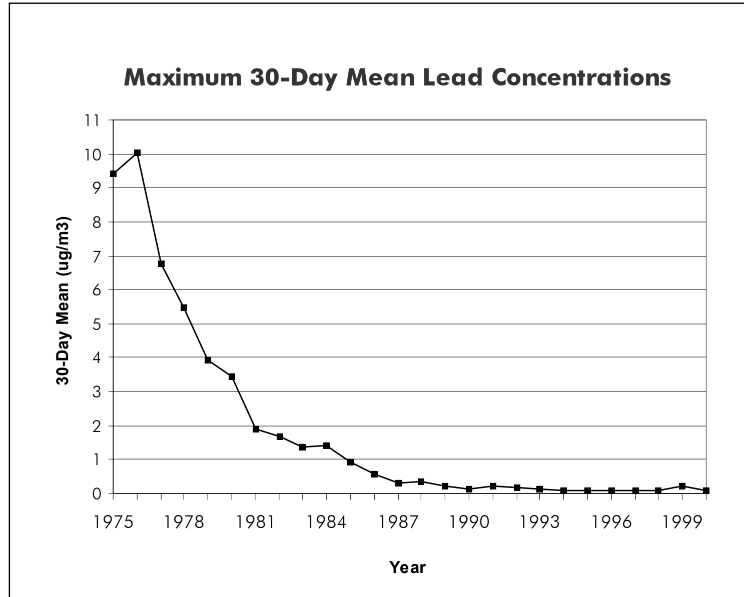

Figure 3-10

Nitrogen Dioxide

Emission Trends and Forecasts - Oxides of Nitrogen

Nitrogen dioxide (NO_2) is a colorless, tasteless gas that can cause lung damage, chronic lung disease, and respiratory infections. Nitrogen dioxide is a component of NO_x, and its presence in the atmosphere can be correlated with emissions of NO_x. Statewide emissions of NO_x are projected to decrease by almost 50 percent from 1985 to 2010 as a result of more stringent emissions standards for stationary source combustion and motor vehicles, and cleaner burning fuels. The introduction of lower emitting vehicles will continue to further reduce NO_x emissions.

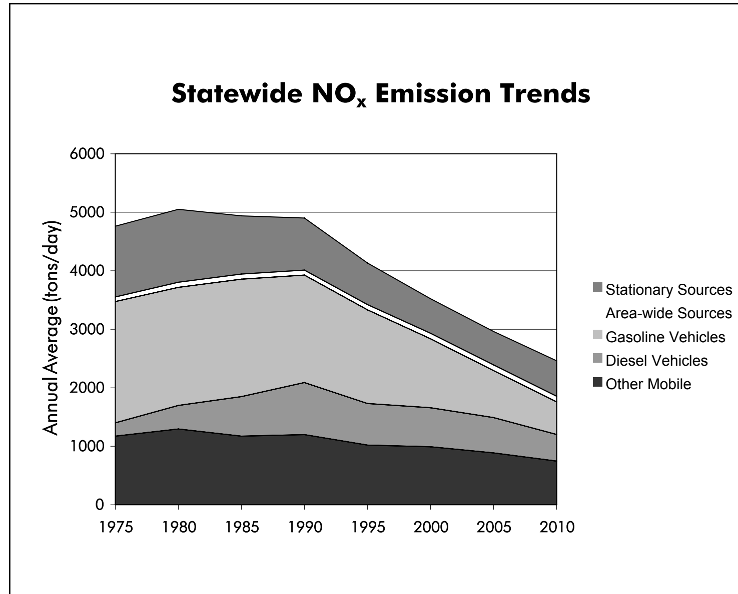

Figure 3-11

Emission Trends and Forecasts - Oxides of Nitrogen

NOx Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	***4762***	***5050***	***4939***	***4901***	***4133***	***3523***	***2962***	***2462***
Stationary Sources	1211	1246	994	889	711	592	571	606
Area-wide Sources	78	88	88	87	89	94	98	97
On-Road Mobile	2300	2422	2684	2727	2312	1846	1408	1012
Gasoline Vehicles	2074	2020	2007	1836	1602	1179	803	559
Diesel Vehicles	226	402	678	890	710	667	604	453
Other Mobile	1173	1294	1172	1199	1020	991	886	747

Table 3-6

Statewide Air Quality - Nitrogen Dioxide

Oxides of nitrogen (NO_x) emissions are a by-product of combustion from both mobile and stationary sources, and they contribute to ambient nitrogen dioxide (NO_2) concentrations. Since 1975, maximum NO_2 concentrations have decreased more than 50 percent, due primarily to the implementation of tighter controls on both mobile and stationary sources. Although many of these controls were implemented to reduce ozone, they also benefited NO_2. All areas of California are currently designated as attainment for the State standard and unclassified/attainment for the national nitrogen dioxide standard. Projections show NO_x emissions will continue to decline, thereby assuring continued attainment.

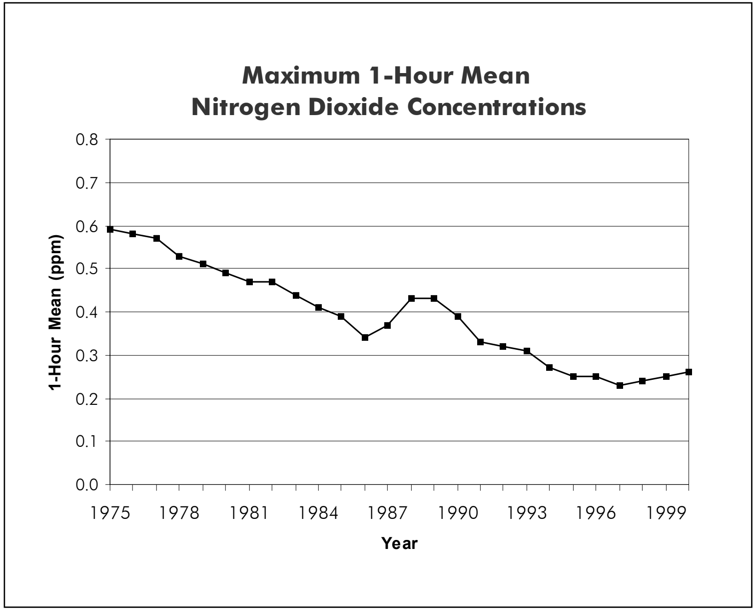

Figure 3-12

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Sulfur Dioxide

Emission Trends and Forecasts - Oxides of Sulfur

SO_x (oxides of sulfur) is a group of compounds of sulfur and oxygen. A major constituent of SO_x is sulfur dioxide (SO_2). Emissions of SO_x declined tremendously in California between 1975 and 2000. Emissions in 2000 are about 75 percent less than emissions in 1975. Sulfur dioxide emissions from stationary sources were decreased between 1975 and 2000 due to improved industrial source controls and switching from fuel oil to natural gas for electric generation and industrial boilers. The SO_x emissions from both gasoline and diesel vehicle exhaust have also decreased due to lower sulfur content in the fuel.

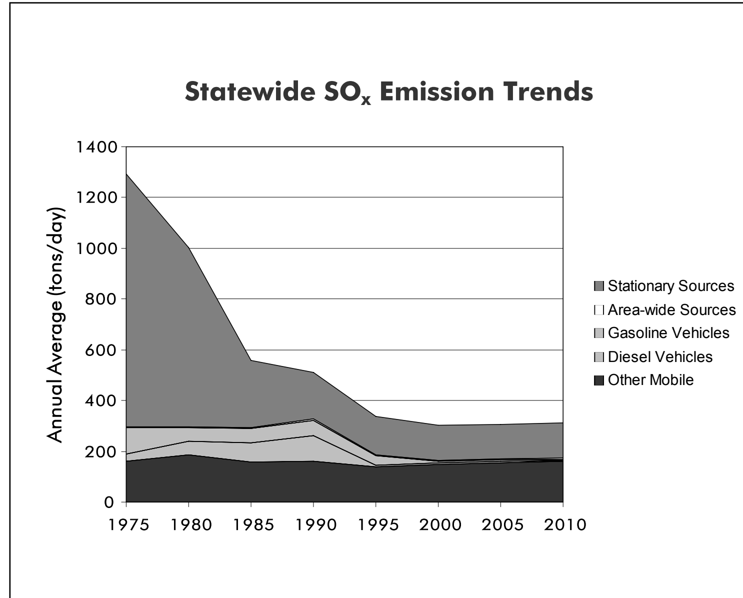

Figure 3-13

Emission Trends and Forecasts - Oxides of Sulfur

SO_x Emission Trends (tons/day, annual average)								
Emission Source	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
All Sources	**1292**	**1002**	**558**	**512**	**337**	**303**	**306**	**312**
Stationary Sources	995	705	264	185	151	139	134	139
Area-wide Sources	3	4	4	5	5	5	5	6
On-Road Mobile	133	107	134	162	43	12	11	5
Gasoline Vehicles	104	53	57	61	36	5	4	4
Diesel Vehicles	29	53	77	101	7	7	7	1
Other Mobile	161	187	156	160	139	148	155	162

Table 3-7

Statewide Air Quality - Sulfur Dioxide

Similar to oxides of nitrogen, oxides of sulfur (SO_x) emissions come from both mobile and stationary sources. These SO_x emissions contribute to ambient sulfur dioxide (SO_2) concentrations. While SO_2 poses significant problems in other parts of the nation, SO_x emissions in California have been reduced sufficiently over the last 25 years so that all areas of California now attain the State standards for sulfur dioxide. Many of the major urban areas are also designated as attainment for the national sulfur dioxide standards. However, most of California is designated as unclassified. With current and anticipated SO_x emission control measures, all areas of the State are expected to remain attainment for SO_2.

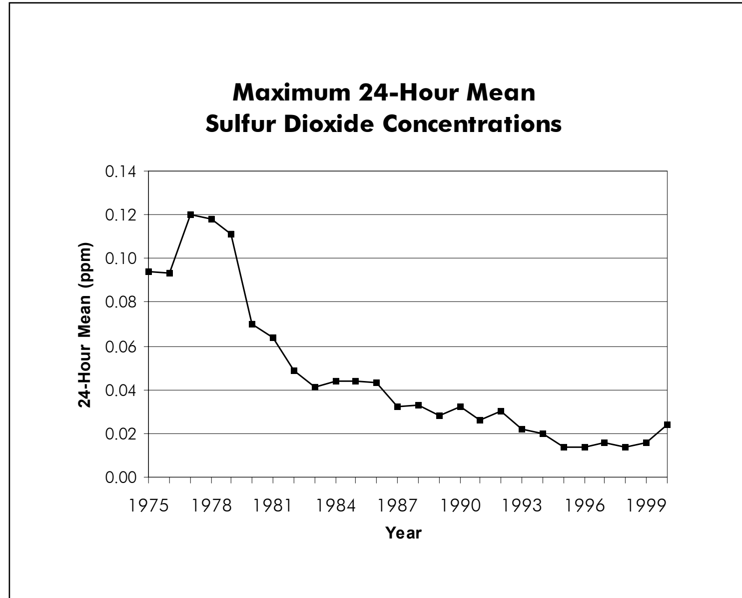

Figure 3-14